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Original Article

CARBON MONOXIDE AIR QUALITY INDEX (AQI-CO) AND SEASONAL TREND (ST-CO) IN CHENNAI TRAFFIC ZONES, INDIA

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ABSTRACT

The present scientific study is to detect the concentration of carbon monoxide and estimate the air quality index (AQI) line with carbon monoxide in the metropolitan Chennai city. The representative monitoring was conducted from January 2018 to December 2018, in the high population locality of Porur (L1), Nerkundram (L2), Thiruvanmiyur (L3), T. Nagar (L4), Vadapalani (L5), Nungambakkam (L6) and Mount road (L7). The multi-gas analyser with Non-dispersive Infra-Red (NDIR) sensor is an automatic and uninterrupted system used for the quantification of CO. In the research, monthly mean assessment of CO indicates, the highest (8.7 mg/m3) and lowest (0.8 mg/m3) level of CO was detected at L5 in the month of October and June respectively, and the annual assessment of CO reveals the observed values are very close to each other at all locations, it implies there is no much different observed between the monitored locations and observed.8 mg/m3 as drifting. The seasonal mean of CO revealed, the highest level of CO detected at L2 during the monsoon and summer season was experienced the lowest value of CO at all locations. The most significant study of AQI-CO is resulted as "moderate category" at L1and L5 during the season of monsoon and pre-monsoon respectively, similar, L2 and L3 laid down under "moderate category" during the season of pre-monsoon, other than these four moderate categories, all location was exhibited "good category" at all seasons. The maximum permissible limit of CO is established as in the term of 8-hours and 1-hour exposure in the NAAQS-CPCB 2009; hence the correlation study between the daily and annual means versus prescribed National specification is questionable. However, the estimated air quality index as per USEPA rule indicates, 86% of the days laid down under "good category" and 14% of the days were a moderate category at selected locations in the Chennai city. Since it was a good category, Chennai was continuously enriching with public and private vehicles, hence the future; all found good categories may extend to "moderate" and observed four moderate categories extend to "unhealthy", hence the governing authority to take appropriate preventing and controlling statistics on the vehicle emission.

KEYWORDS: CO, AQI, CPCB, EPA, NDIR & CO-Hb

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INTRODUCTION

Carbon monoxide is an odourless, colourless, tasteless, flammable and non-irritating poisonous gas released from incomplete flaming of hydrocarbons products used as fuels in the transports. Vehicle mission is responsible for 60% of CO in the atmosphere, another major part of CO emitted from industrial activities. In the industrial, incomplete combustion of fuels, solid waste and incinerating process were emitting the CO to the atmosphere (WHO, 1990 & Von Burg, 1999). Globally, vehicular emission releases 90 to 95 % of CO to the

atmospheric air (He, et al., 2002, & Mahlia, et al., 2013). In the US and EU, declared the carbon monoxide is an accidental and suicidal poising gas to leads the death. Long-term exposure of CO reduces the oxygen level in the haemoglobin to produce the carboxy haemoglobin (Bascom, 1996). The usage of fossil fuels was increased in the last century, is liable for the continuous inconstancy in the atmospheric composition. Evidenced, either long term or short term exposures have been associated with chronic respiratory disease, lung cancer, persistent bronchitis, asthma, skin allergy; aggravate heart morbidity and early mortality (Marilena Kampa, et al. 2008). Gas pollutants have a significant contribution to atmospheric composition diversity (Katsouyanni, 2003). The CO is an imperative waving unit in physiological behaviour and its toxic nature alike cyanide (Troxler, 1972). In the city, 90% of CO transmitted from vehicle emission and the highest level of CO is recorded during the rush hours at just after morning and evening. An elevated level of CO is harmful to the mammals and when entering the CO to the bloodstream, decrease the oxygen level in the blood supplied to the tissues, brain and heart, to leads the mantle dysfunction and premature death (USEPA, 1991). Universally, carbon monoxide extended from 0.06 to 0.14 mg/m3 and found 1-2% increased per annum and owning vital chronological affiliation with volatile organic compounds and nitrogen oxides. It is decreased with increasing the distance from the traffic zone (Rudolf, 1994, Derwent, et al., 1995). The people who have continued the roadside work, like drivers, a traffic policeman, garage and subway workers, roadside shoppers, road mechanic and road surveyor were undergoing the high-level CO exposure. During a medical survey, more oxygen deficiency and the high level of carboxyhaemoglobin was observed in a blood sample collected from those persons (USEPA, 1991). Once reached lungs, carbon monoxide scattered quickly through the capillary, placental and alveolar membranes. It also readily binds with haem proteins and reducing the oxygen-carrying capacity of the blood. The binding of carbon monoxide with haemoglobin is 250 times greater than the oxygen binding (ACGIH, 1991). Acute poisoning of CO can cause revocable and short-lasting neurological damage, headache, dizziness, nausea, vomiting and coma (Benignus, 1994). It is responsible for poisoning deaths during the Cold season and recorded 1513 deaths due to the exposure of 500ppm of CO during the period of 1979 to 1988 in the USA (WHO, 1990). The death rate and adverse health impact of unintentional poisoning of CO differ with its ppm level and exposure period (Varon, et al., 1999)). Short-term exposure of 10 to 100 ppm of CO causes an adverse reaction between CO and haemoglobin in the blood cell, to produce Carboxyhemoglobin (CO-Hb). This CO-Hb, reduce the oxygen-carrying level in the blood supplied to heart, brain and tissues. Further, cytochrome oxidation of CO reduces the oxygen utilization capability of cells in the body (Von Burg, 1999). Long term exposure of low-level CO (< 10 ppm) leads respiratory, cardiovascular and neurobehavioral diseases and high-level CO (> 500ppm) leads coma and death (Kurt, et al., 1978 & Kuller, et al., 1975). In 1976, winter and Miller have derived a correlation between the atmospheric CO (ppm) and blood CO (%) in “Table 1”.

Table 1: Correlation between the Atmospheric CO (ppm) and Blood CO (%)

Atmosphere CO (ppm)	Blood CO (%)	Signs and Symptoms
10	2	Asymptomatic
70	10	No substantial effect, except shortness of breath on forceful exertion, possible tightness across the forehead and stretching of blood vessels.
120	20	Shortness of breath on moderate exertion and irregular headache.
220	30	Decide headache, irritable, easily fatigued, possible dizziness, judgment disturbed and weakness of vision
350 - 520	40 – 50	Headache, confusion, collapse and fainting on exertion
800 - 1220	60 – 70	Unconsciousness, respiratory failure convulsion, intermittent, and death if long term exposure.
1950	80	Rapidly fatal

Even with powerful International and national events were conducting for regulating the ambient CO levels, CO exposure is still harmful to human health, especially those who work near traffic. There was much direct research and survey were reported, many occupational and environmental adverse health effects due to the exposure of carbon monoxide. CO is irreversibly binding with Haemoglobin to form CO-Hb and create the oxygen demand in the blood. Hence it is considered as accidental and unintentional poisonous to all mammal health. Such a dangerous CO affects the major organs like the brain and skeletal tissues, so, this research aimed to find the CO level in various tremendous traffic zones in Chennai city.

MATERIALS AND METHODS

Study Area

Chennai metropolitan city is a capital of Tamil Nadu and binding with commercial, industrial, residential and ecologically sensitive sectors. It is the smallest district with 426 Km2 areas, but having a large population, east side fenced by the Bay of Bengal and another three sides were surrounded by land (Prabakaran et al., 2019). The monitoring was conducted in the representative location of Porur (L1), Nerkundram (L2), Thiruvanmiyur (L3), T. Nagar (L4), Vadapalani (L5), Nungambakkam (L6) and Mount road (L7). These selected locations were encountering 24 X 7 vehicle movements with heavy traffic. The significant seasonal segments were observed, such as post-monsoon (January to March), summer (April to June), pre-monsoon(July to September) and monsoon (October to December). The past ten years, increased the extraordinary growth in the industrialization, commercial, trading, vehicular population and migration of population in the urban locality (Prabakaran, et al., 2017).

Carbon Monoxide

Carbon monoxide measured by using multi-gas analyser with Non-dispersive Infrared (NDIR) sensor. The NDIR sensor is an automatic and uninterrupted system, it works based on the absorption of infrared radiation by the CO molecule (Feldstein, 1967). This multi-gas analyser incorporated with a selective gas filter to eliminate or reduce the interference raised from other gases like carbon dioxide, water vapour, oxides of nitrogen and sulphur. Further, the 0.25micron filter attached in the probe to prevent the entering of micro particles. This multi-gas analyser has a resolution at 0.1 ppm.

Air Quality Index

The air quality index is an effective tool to assess the health impact of each air pollutants into a single number or set of numbers (Prabakaran, et al., 2017). AQI was calculated by using the formula as below, which is established by the environmental protection agency in USA and location were categorised based on the “Table 2”.

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

Where,

C_{low} is the concentration break point; it is less than equal to the concentration of observed pollutants,

C_{high} is the concentration break point, it is greater than equal to the concentration of observed pollutants,

I_{low} is the index breakpoint corresponding to lower concentration of observed pollutants.

I_{high} is the index breakpoint corresponding to higher concentration of observed pollutants

Table 2: Air Quality Index Classification (Source EPA)

CO (ppm)	AQI	AQI
C_{low} - C_{high}	I_{low} - I_{high}	**Category**
0.0-4.4	0-50	Good
4.5-9.4	51-100	Moderate
9.5-12.4	101-150	Unhealthy for Sensitive Groups
12.5-15.4	151-200	Unhealthy
15.5-30.4	201-300	Very Unhealthy
30.5-40.4	301-400	Hazardous
40.5-50.4	401-500	

RESULTS AND DISCUSSIONS

This study aims to quantify the carbon monoxide in the Chennai city during the period from January 2018 to December 2018. Significantly, the concentration of carbon monoxide in representative and high population locations of Porur (L1), Nerkundram (L2), Thiruvanmiyur (L3), T. Nagar (L4), Vadapalani (L5), Nungambakkam (L6) and Mount road (L7) were quantified. Monitoring was conducted twice in a week for the entire year and completed 104 measurements as per the NAAQS protocol. From the obtained result, calculated the monthly mean, annual mean and seasonal mean at all selected locations and estimated the seasonal variation and air quality index. Subsequently, the monitored location was categorized with respect to the obtained AQI values.

Monthly and Annual Mean Assessment

Monthly mean of CO at each location was graphically represented in figure-1. During the period from January 2018 to December 2018, the monthly mean of CO varied from 1.3 to 7.0 mg/m3, 1.9 to 6.1mg/m3, 1.5 to 7.1 mg/m3, 1.3 to 5.7 mg/m3, 0.8 to 8.7 mg/m3, 1.4 to 6.4 mg/m3 and 1.0 to 8.4 mg/m3 at L1, L2, L3, L4, L5, L6 and L7, respectively. When comparing the monitored locations, the highest (8.7 mg/m3) and lowest (0.8 mg/m3) level of CO was detected at L5 in the month of October and Jun respectively. The annual mean of CO at selected locations was graphically pictured in figure 3, in this study, the annual mean CO resulted as 3.5 mg/m3 at L1, 3.9 mg/m3 at L2, 3.7 mg/m3 at L3, 3.3 mg/m3 at L4, 4.1 mg/m3 at L5, 3.9 mg/m3 at L6 and 3.9 mg/m3 at L7 was observed. Annual mean of CO at locations was significantly close to each other, there is no much different observed between the locations, it is varied from 3.3 mg/m3 to 4.1 mg/m3.

Seasonal Assessment

In this study, the detected level of CO during the season of post-monsoon, summer, pre-monsoon and monsoon in the year of 2018 are given in “Table 3”and “Table 4”. During the post monsoon, CO level ranged from 0.2 to 7.4 mg/m3, 0.2 to 12.3 mg/m3, 0.2 to 7.4 mg/m3, 0.2 to 9.4 mg/m3, 0.2 to 9.2 mg/m3, 0.4 to 14.2 mg/m3 and 0.2 to 8.9 mg/m3 at L1, L2, L3, L4, L5 and L6 respectively, during the summer, CO level varied from 0.2 to 5.1 mg/m3, 0.1 to 8.3 mg/m3, 0.1 to 6.2 mg/m3, 0.1 to 6.2 mg/m3, 0.2 to 4.3 mg/m3, 0.1 to 6.2 mg/m3 and 0.1 to 6.5 mg/m3 at L1, L2, L3, L4, L5 and L6 respectively. During pre-monsoon, the CO level detected as 0.2 to 12.1 mg/m3 at L1, 0.2 to 15.2 mg/m3 at L2, 0.2 to 13.2 mg/m3 at L3, 0.1 to 12.2 mg/m3 at L4, 0.2 to 18.2 mg/m3 at L5, 0.2 to 13.5 mg/m3 at L6 and 0.1 to 11.8 mg/m3 at L7. At last monsoon season exposed from 0.2 to 16.1 mg/m3 at L1, 0.2 to 17.4 mg/m3 at L2, 0.1 to 16.5 mg/m3 at L3, 0.1 to 13.8 mg/m3 at L4, 0.2 to 12.5 mg/m3 at L5, 1.5 to 11.3 mg/m3 at L6 and 1.5 to 11.3 mg/m3 at L7.

Air Quality Index

The seasonal mean of CO at selected locations were assessed in term of the index number with respect to the obtained results. The result of seasonal AQI-CO at all seasons was given in “Table 5”. The present research indicates the seasonal AQI-CO is differing from 33.7 to 55.7, 15.2 to 29.1, 33.2 to 53.7 and 41.3 to 51.7 for the season of post-monsoon, summer, pre-monsoon and monsoon respectively. The comparison of average seasonal AQI-CO was graphically represented in figure-3, the highest AQI-CO was detected at L5 during post-monsoon and lowest AQI-CO was found at L5 during the season of summer. This AQI-CO assessment revealed four “moderate category”, such as during monsoon at L1, during pre-monsoon at L2 and L3, during post-monsoon at L5. Except for these four "moderate category", all the locations at all seasons were exposed as “good category.

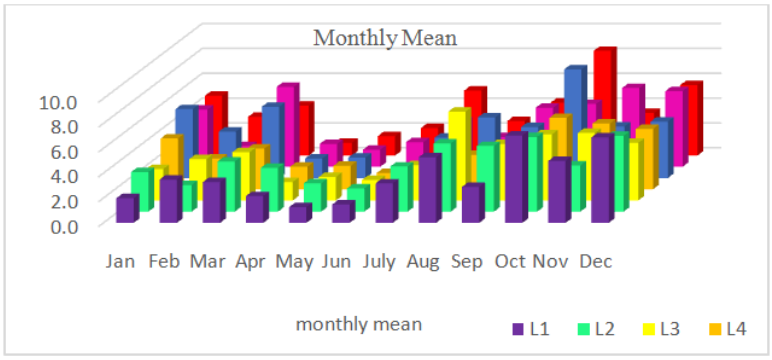

Figure 1: Monthly Mean of CO in Chennai City from January 2018-December 2018

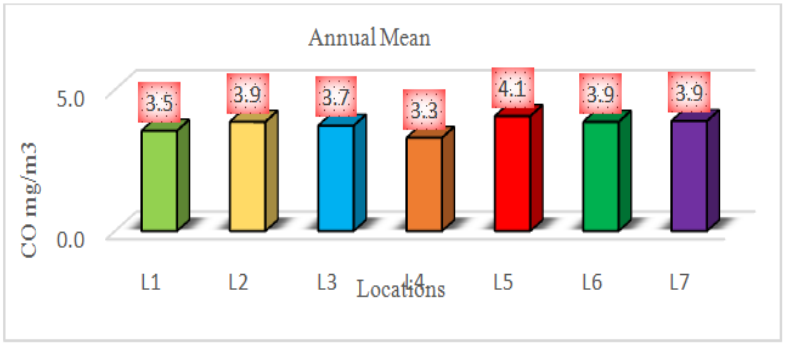

Figure 2: Annual Mean of CO in Chennai City from January 2018-December 2018

Table 3: Seasonal Mean of CO – Post Monsoon and summer in 2018

Location	Post Monsoon (Jan to Mar)			Summer (Apr to Jun)		
	Min	Max	Mean	Min	Max	Mean
L1	0.2	7.4	2.9	0.2	5.1	1.6
L2	0.2	12.3	3.1	0.1	8.3	2.6
L3	0.2	7.4	3.2	0.1	6.2	1.7
L4	0.2	9.4	2.1	0.1	6.2	1.7
L5	0.2	9.2	5.0	0.2	4.3	1.3
L6	0.4	14.2	4.2	0.1	6.2	1.7
L7	0.2	8.9	4.0	0.1	6.5	1.6
L1	0.2	7.4	2.9	0.2	5.1	1.6

Table 4: Seasonal Mean of CO – Pre Monsoon and Monsoon in 2018

Location	Pre Monsoon (Jul to Sep)			Monsoon (Oct to Dec)		
	Min	Max	Mean	Min	Max	Mean
L1	0.20	12.10	3.78	0.20	16.10	6.30
L2	0.20	15.2	4.80	0.20	17.4	4.94
L3	0.2	13.20	4.84	0.1	16.50	5.13
L4	0.1	12.2	2.93	0.1	13.8	5.30
L5	0.2	13.2	4.1	0.2	12.5	5.8
L6	0.2	13.5	3.60	1.50	11.30	5.83
L7	0.1	11.8	4.1	1.50	11.30	5.8
L1	0.20	12.10	3.78	0.20	16.10	6.30

Table 5: Carbon Monoxide Air Quality Index at Chennai city, 2018

Location	Post-Monsoon		Summer		Pre-Monsoon		Monsoon	
	AQI	Category	AQI	Category	AQI	Category	AQI	Category
L1	33.7	Good	18.6	Good	42.6	Good	51.7	Moderate
L2	35.5	Good	29.1	Good	53.7	Moderate	41.3	Good
L3	36.8	Good	19.0	Good	53.7	Moderate	42.9	Good
L4	37.2	Good	19.0	Good	33.2	Good	44.2	Good
L5	55.7	Moderate	15.2	Good	46.1	Good	48.0	Good
L6	47.2	Good	19.7	Good	40.8	Good	48.2	Good
L7	45.1	Good	18.3	Good	46.1	Good	48.0	Good

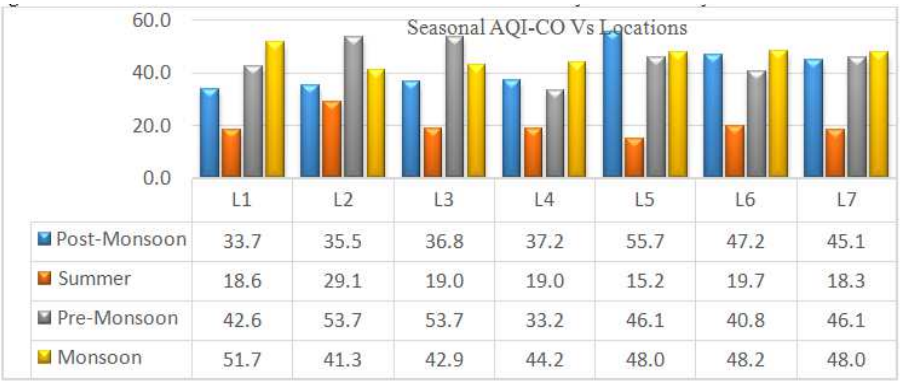

Figure 3: Seasonal variation Annual Mean of CO in Chennai City from January 2018-December 2018

CONCLUSIONS

Carbon monoxide is an accidental and suicidal poising gas, to lead the death by reducing the oxygen level in the haemoglobin to produce the carboxy haemoglobin in the mammals. Various worldwide environmental studies stated, the 90% of CO emitted to the atmosphere from vehicle emission, all those implies, the urban localities was always knotted with unintentional life threatening due to CO pollution, hence the suitable periodical environmental monitoring is required to assess the ground-level air pollution at representative sampling points in every urban city. In the research, monthly mean assessment of CO indicates, the highest (8.7 mg/m3) and lowest (0.8 mg/m3) level of CO was detected at L5 in the month of October and Jun respectively, and the annual assessment of CO reveals the observed values are very close to each other at all locations. It implies there is no much different observed between the locations and observed the drifting is 0.8 mg/m3 only. This annual assessment reveals all monitored locations are equally polluted with CO. The seasonal mean of CO revealed, the highest level of CO detected at L2 during the monsoon and summer season experienced the lowest value of CO at all locations. The most significant study of AQI-CO is resulted as “moderate category” at L1and L5 during the

season of monsoon and pre-monsoon respectively, similar, L2 and L3 laid down under moderate category during the season of pre-monsoon, other than these four moderate categories, all location was exhibited “good category” at all seasons. The maximum permissible limit of CO is established as in the term of 8-hours, and 1-hour exposure in the National ambient air quality standards, CPCB 2009, hence the correlation study between the daily and annual means versus prescribed National specification is questionable. However, the estimated air quality index as per EPA rule indicates, 86% of the days laid down under “good category” and 14% of the days were a moderate category at selected locations in the Chennai city. Since it was a good category, Chennai was continuously enriching with public and private vehicles, hence the future; all found good categories may extend to "moderate" and observed four moderate categories extend to "unhealthy", hence the governing authority to take appropriate preventing and controlling statistics on the vehicle emission.

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